L7: Entry 4 of 23 File: JPAB Apr 28, 1997

PUB-NO: JP409111344A
DOCUMENT-IDENTIFIER: JP 09111344 A
TITLE: PRODUCTION OF HIGH STRENGTH AND LOW YIELD RATIO SEAMLESS STEEL PIPE

PUBN-DATE: April 28, 1997

INVENTOR-INFORMATION:

NAME	COUNTRY
YAGI, AKIRA	

INT-CL (IPC): C21 D 8/10; C22 C 38/00; C22 C 38/14; C22 C 38/54; C22 C 38/58

ABSTRACT:

PROBLEM TO BE SOLVED: To provide a method or producing a high toughness seamless steel pipe having high strength and low yield ratio, furthermore excellent in SSC (suphide stress cracking) resistance or more over having a fine-grained structure by regulating the steel components and rolling-heat treating conditions.

SOLUTION: A slab contd., by weight, 0.02 to 0.2% C, 0.01 to 0.5% Si, 0.15 to 2.5% Mn, ≤0.02% P, ≤0.01% S, 0.005 to 0.1% Al, ≤0.01% N and 0.005 to 0.1% Ti and furthermore contg. one or ≥two kinds among Cr, Mo, Ni, V, B, rare earth metals, Ca, Co and Cu according to necessity is formed into a hollow pipe stock by hot piercing continuous rolling, which is next subjected to finish rolling to produce a finished steel pipe. This steel pipe is subjected to quenching treatment of executing rapid cooling from the Ar3 point or above, is thereafter heated to between the Ac1 point and the Ac3 point, is rapidly cooled and is then subjected to tempering treatment of executing heating to the Ac1 point or below and executing cooling.

(19)日本国特許庁（ＪＰ）

(12) **公開特許公報**（Ａ）

(11)特許出願公開番号

特開平9－111344

(43)公開日　平成９年(1997)４月28日

(51)Int.Cl.^{6}	識別記号	庁内整理番号	ＦＩ	技術表示箇所
Ｃ２１Ｄ　8/10		9270－4K	Ｃ２１Ｄ　8/10	Ｂ
Ｃ２２Ｃ　38/00	３０１		Ｃ２２Ｃ　38/00	３０１Ｚ
38/14			38/14	
38/54			38/54	
38/58			38/58	

審査請求　未請求　請求項の数３　ＯＬ　（全 ６ 頁）

(21)出願番号　特願平7－270332

(22)出願日　平成７年(1995)10月18日

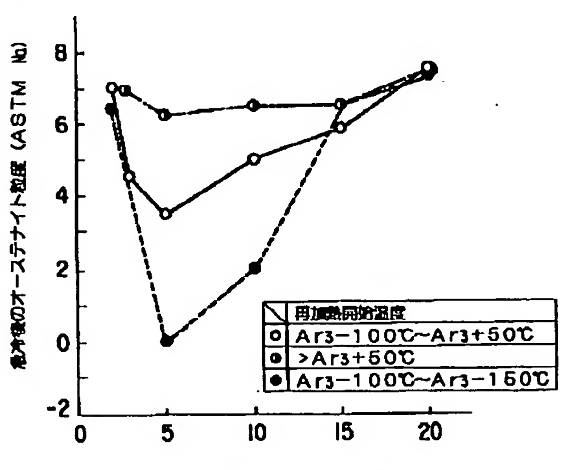
(71)出願人　000006655
新日本製鐵株式会社
東京都千代田区大手町２丁目６番３号

(72)発明者　八木　明
福岡県北九州市戸畑区飛幡町１番１号　新日本製鐵株式会社八幡製鐵所内

(74)代理人　弁理士　田村　弘明　（外１名）

(54)【発明の名称】　高強度で且つ低降伏比シームレス鋼管の製造方法

(57)【要約】
【課題】　本発明は鋼成分や圧延・熱処理条件を制御することにより高強度で且つ低降伏比のシームレス鋼管、更には耐ＳＳＣ性に優れ、或いは更に細粒組織をもった高靭性シームレス鋼管の製造法を提供する。
【解決手段】　重量%として、C:0.02/0.2、Si:0.01/0.5 、Mn:0.15/2.5 、 P≦0.02、 S≦0.01、Al:0.005/0.1、 N≦0.01、およびTi:0.005/0.1を含有し、さらにCr,Mo,Ni,V,B,REM,Ca,Co,Cu の１種または２種以上を必要に応じて含有してなる鋼片を、熱間穿孔連続圧延で中空素管とし、次いで仕上圧延して仕上鋼管を製造し、この鋼管をＡｒ$_3$ 点以上の温度から急冷する焼入れ処理を施した後、Ａｃ$_1$ ～Ａｃ$_3$ 点間の温度に加熱してから急冷し、次いでＡｃ$_1$ 点以下の温度に加熱冷却する焼戻し処理を行うことを特徴とする。



1

【特許請求の範囲】

【請求項1】　重量%として、

C　：0．02%～0．20%、
Si：0．01%～0．5%、
Mn：0．15%～2．5%、
P　：0．020%以下、
S　：0．010%以下、
Al：0．005%～0．1%、
Ti：0．005%～0．1%、
N　：0．01%以下

を含有し、残部が実質的にFeよりなる鋼片を、熱間穿孔連続圧延の最終過程で900～700℃の温度で圧下率3～15%の加工を施し、Ar_3 点－100℃～Ar_3 点＋50℃の温度に降下させた中空素管を、該素管温度より高い900～1000℃の間に加熱してから、仕上温度がAr_3 点＋50℃以上の熱間仕上圧延を施し、得られた仕上鋼管をAr_3 点以上の温度から急冷する焼入れ処理を施した後、Ac_1 ～Ac_3 点間の温度に加熱してから急冷し、次いでAc_1 点以下の温度に加熱冷却する焼戻し処理を行うことを特徴とする高強度で且つ低降伏比シームレス鋼管の製造方法。

【請求項2】　鋼片成分としてさらに、重量%として

Cr：0．1%～1．5%、
Mo：0．05%～0．5%、
Ni：0．1%～2．0%、
V　：0．01%～0．1%
B　：0．0003%～0．0030%

からなる群の元素より選ばれた少なくとも1種を含有することを特徴とする請求項1記載の高強度で且つ低降伏比シームレス鋼管の製造方法。

【請求項3】　鋼片成分としてさらに、重量%として

希土類元素：0．001%～0．05%、
Ca：0．001%～0．02%、
Co：0．05%～0．5%、
Cu：0．1%～0．5%

からなる群の元素より選ばれた少なくとも1種を含有することを特徴とする請求項1或いは2記載の高強度で且つ低降伏比シームレス鋼管の製造方法。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明は、高強度で且つ低降伏比であるシームレス鋼管の製造方法に関するものである。

2

【0002】

【従来の技術】油井等の掘削用或いは石油や天然ガスを搬送するラインパイプ等に使用されるシームレス鋼管は、破壊に対する安全性を向上させる観点から、降伏比の低い特性が要求される。熱延シームレス鋼管で低降伏比鋼管とするには、圧延ままか、または圧延後オーステナイト域まで再加熱し空冷する焼ならし処理を行い、組織的にフェライト・パーライトの2層組織にする方法がある。しかしこのような方法ではいずれにおいてもAPI－Xグレードの高強度は得られない。一方、高強度化するために焼入れ－焼戻し処理をすると低降伏比が達成できないという問題があった。

【0003】この様な問題を解決するために、特開平2－282427号公報には、常温でフェライトとパーライトの混合組織を有する鋼をAc_1 変態点＋10℃からAc_1 変態点＋90℃の温度に加熱、保定後急速冷却処理を施し、その後焼戻し処理をする最高硬さと降伏比の低い高強度鋼管の製造法が開示されている。また、「材料とプロセス」（No.3,Vol.4,1991 日本鉄鋼協会・第121回（春季）講演大会予稿 552）にはシームレス工程で圧延されたNb－Mo系鋼管を、焼入(930℃×10min水冷）処理材（ベイナイト主体組織）から2層温度域に加熱・水冷－焼戻して低降伏比材を得ることが提示されている。さらに特開平3－64415号公報では、TiおよびNbを含有する鋼片を穿孔圧延し、温度降下した素管を再加熱して仕上圧延した後、焼き入れ、焼戻し処理して細粒組織の高靭性シームレス鋼管の製造法が開示されている。

【0004】

【発明が解決しようとする課題】しかし、熱間のシームレス圧延では、圧延後のオーステナイト結晶粒度がASTM No.1～6とばらつきが大きいため、上記熱処理を施しても強度、降伏比の安定したシームレス鋼管が得られないという問題があった。本発明はこの様な問題を解消するものであって、鋼成分や圧延・熱処理条件を制御することにより安定した高強度で且つ低降伏比のシームレス鋼管の製造法を提供することを目的とする。

【0005】

【課題を解決するための手段】すなわち本発明は、以下の構成を要旨とする。重量%として、

C　：0．02%～0．20%、　Si：0．01%～0．5%、
Mn：0．15%～2．5%、　P　：0．020%以下、
S　：0．010%以下、　Al：0．005%～0．1%、
Ti：0．005%～0．1%、　N　：0．01%以下、

を含有し、更に必要に応じて

Cr：0．1%～1．5%、　Mo：0．05%～0．5%、
Ni：0．1%～2．0%、　V　：0．01%～0．1%
B　：0．0003%～0．0030%

からなる第1群元素と、希土類元素：0．001%～0．05%、Ca：0．001%～0．02%、Co：0．05%～0．5%、Cu：0．1%～0．5%からなる第2群元素であって、この両群より選ばれた少なくとも一種を含有し、残部が実質的にFeよりなる鋼片を、熱間穿孔連続圧延の最終過程で900～700℃の温度で圧下率3～15%の加工を施し、Ar_3 点－100℃～Ar_3 点＋50℃の温度に降下させた中空素管を、該素管温度より高い900～1000℃の間に加熱してから、仕上温度がAr_3 点＋50℃以上の熱間仕上圧延を施し、得られた仕上鋼管をAr_3 点以上の温度から急冷する焼入れ処理を施した後、Ac_1 ～Ac_3 点間の温度に加熱してから急却し、次いでAc_1 点以下の温度に加熱冷却する焼戻し処理を行うことを特徴とする高強度で且つ低降伏比シームレス鋼管の製造法である。

【0006】

【発明の実施の形態】以下本発明の製造法について詳細に説明する。先ず、本発明において上記のような鋼成分に限定した理由について説明する。C，Mnは、焼入れ効果を増して強度を高め降伏点40～60kgf/mm² の高張力鋼を安定して得るためおよび降伏比を低下させるため重要である。少な過ぎるとその効果がなく、多過ぎると焼割れの誘発および高硬度化し耐SSC性の低下をきたすためそれぞれ0．02～0．20%、0．15～2．5%とした。

【0007】Siは、脱酸剤が残存したもので強度を高めるためおよび降伏比を低下させる有効な成分である。少な過ぎるとその効果がなく、多過ぎると介在物を増加して耐SSC性を低下させるため0．01～0．5%とした。

【0008】Pは、粒界偏析を起こして加工の際き裂を生じやすく有害な成分であり、また低温靭性の劣化をきたすためその含有量を0．020%以下とした。Sは、MnS系介在物を形成して熱間連続圧延で延伸し層状組織を形成し、鋼の破壊伝播性能を改善する。少な過ぎるとその効果がなく、多過ぎると介在物を増加して鋼の性質を脆化するため0．01%とした。

【0009】Alは、Siと同様脱酸剤が残存したもので、鋼中の不純物成分として含まれるNと結合して結晶粒の成長を抑えて鋼の破壊伝播性能を改善する。少な過ぎるとその効果がなく、多過ぎると介在物を増加して鋼の性質を脆化するため0．005～0．1%とした。

【0010】Tiは、シームレス圧延中の結晶粒径制御元素として最も重要な元素である。Tiは、鋼中の不純物成分として含まれるNと結合して、熱間圧延中の結晶粒制御および熱間圧延後の結晶粒の成長を抑え鋼の破壊伝播性能を改善すると共に、脱酸、脱窒の作用から後述のBの焼入れ性を発揮させ強度を高める。少な過ぎるとその効果がなく、多過ぎるとTiCを析出して鋼を脆化させるため0．005～0．1%とした。Nは、後述のBの焼入れ性を低下させる有害な成分としてその含有量を0．01%以下とした。

【0011】上記の成分組成の鋼で更に鋼の強度を高める場合Cr等の成分を必要に応じて選択的に添加する。Cr，Mo，Ni，Vは、鋼の焼入れ性を増して、強度を高めるために添加するものである。少な過ぎるとその効果がなく、多過ぎてもその効果が飽和し、しかも非常に高価であるため、それぞれについて上，下限を限定し、Crは0．1～1．5%、Moは0．05～0．5%、Niは0．1～2．0%、Vは0．01～0．1%とした。またBは、焼入れ性を著しく向上せしめて強度を高める。少な過ぎるとその効果がなく、多過ぎても効果は変わらない一方、靭性や熱間加工性を劣化させるのでその含有範囲を0．0003～0．0030%とした。上記CrないしBの各元素は必要に応じて選択的に添加すれば良い。

【0012】更に本発明は、近年のシームレス鋼管の使用環境を鑑み上記の成分組成で構成される鋼の耐SSC性を改善するために希土類元素，Ca，Co，Cu等の成分を必要に応じて選択的に添加する。希土類元素、Caは、介在物の形態を球状化させて無害化する有効な成分である。少な過ぎるとその効果がなく、多過ぎると介在物を増加して耐SSC性を低下させるので希土類元素は0．001～0．05%、Caは0．001～0．02%とした。Co，Cuは、鋼中への水素侵入抑制効果があり耐SSC性に有効に働く。少な過ぎるとその効果がなく、多過ぎるとその効果が飽和するためCoは0．05～0．5%、Cuは0．1～0．5%とした。

【0013】次に熱間シームレス圧延条件を上記のように限定した理由について説明する。上記のような成分組成の鋼は転炉、電気炉等の溶解炉で或いは更に真空脱ガス処理を経て溶製され、連続鋳造法又は造塊分塊法で鋼片を製造する。鋼片は、直ちに或いは一旦冷却された後高温に加熱し熱間穿孔圧延を行う。加熱温度は、熱間穿孔圧延を容易にするため十分高くしておかなければならない。本発明成分範囲内の鋼であれば1200℃以上の温度で熱間穿孔加工してもなんら支障が生じないため、その加熱温度は1000～1250℃とした。

【0014】熱間鋼片は穿孔圧延後熱間連続圧延機に搬送され、目標の外径、肉厚に圧延されて中空素管に粗成形する。この圧延は、製管された鋼管の材質、特に結晶粒度、降伏比に大きな影響を及ぼす。図1および図2は圧延直後のオーステナイト粒度を調べるため圧延後に急冷処理した鋼管（表1　鋼 No.5の成分）のγ粒度と熱間穿孔連続圧延の最終過程での圧延条件、再加熱開始温度、再加熱炉温度との関係を示す。図に示すように圧延直後のγ粒度は、各条件により、ASTM No.0～8と大きく変化する。

【0015】本発明等の研究によると、API　Xグレード級の高強度鋼の降伏比は、焼入れ処理前の結晶粒度

5

に影響され結晶粒径が比較的大きいほど降伏比は低下すること、そして、降伏比とラインパイプ材などで要求される低温靭性を満足するγ粒度はＡＳＴＭ No.３～５とする必要があることを突き止めた。また、ＡＳＴＭ No.３～５のγ粒度を得るには熱間穿孔連続圧延の最終過程から再加熱で起こる歪誘起粒成長後の二次再結晶により引き起こされるγ粒粗大化現象の利用が不可欠であることを見出だした。

【００１６】歪み誘起粒成長を利用したγ粒度制御は、熱間穿孔連続圧延の最終過程での圧延条件、再加熱開始温度、再加熱炉温度を以下のように規定することにより可能となる。すなわち、熱間穿孔連続圧延の最終圧延での圧下温度は９００℃超では加工により導入された歪みエネルギーが回復、再結晶により低下するため歪み誘起粒成長の駆動力が消失するため結晶粒径の粗大化が起こらず、鋼管の降伏比の低下を阻害する。よって、熱間穿孔連続圧延の最終過程での圧下温度は９００～７００℃に限定する。

【００１７】かかる熱間穿孔連続圧延において、圧下量が0～2%では歪み誘起粒成長の駆動力が不十分であり、１５%以上では蓄積される歪みエネルギーが大きくなり過ぎて圧下後或いはその後の再加熱過程で歪みエネルギーを持たないγ粒の成長により歪み誘起粒成長の駆動力が消失するため、結晶粒径の粗大化が起こらず鋼管の降伏比の低下を阻害する。よって、熱間穿孔連続圧延の最終過程での圧下量は3～１５%に限定した。

【００１８】圧下後８５０℃～Ａr_1 点の温度に降下した中空粗管は、再加熱されて仕上圧延されるが、この再加熱開始温度は、Ａr_3 －１００℃～Ａr_3 －１５０℃ではγ粒の急激な異常粗大化が起こり低温靭性が著しく劣化し、また、Ａr_3 ＋５０℃では歪み誘起粒成長の駆動力が消失し適度なγ粒粗大化が起こらず、鋼管の降伏比の低下を阻害する。よって、圧下後の再加熱開始温度はＡr_3 －１００℃～Ａr_3 ＋５０℃にする。一方、再加熱温度は９００℃未満ではγ粒の成長に不十分であると共に熱間最終仕上圧延後の焼入れ温度が確保できず、また１０００℃を超えてはγ粒の急激な粗大化が起き、低温靭性が著しく劣化すると共に鋼表面に多量の酸化スケールが生じ鋼管の表面品位に悪影響を及ぼす。よって、仕上圧延時の再加熱温度は９００℃～１０００℃の温度にする。

6

【００１９】９００～１０００℃に加熱された中空素管には仕上温度がＡr_3 点＋５０℃以上となる熱間最終仕上圧延を施し、得られた仕上鋼管に焼入れ処理が施される。熱間最終仕上圧延後の冷却開始温度は、安定した十分な焼入れ組織となり、必要とする強度、耐サワー性および靭性を確保し、且つ焼入れ処理後に行うＡc_3 ～Ａc_1 点からの急冷処理で得られる組織の均一性を確保する必要性からＡr_3 点＋５０℃以上とする。

【００２０】Ａr_3 点＋５０℃以上から急冷する焼入れ処理を施した後、続いてＡc_3 ～Ａc_1 点に再加熱しその後急冷処理を施す。この処理は、細粒組織の高強度且つ低降伏比を得るための本発明上重要な工程である。再加熱温度は、目標とする強度、降伏比に大きく影響する。この温度はＡc_3 ～Ａc_1 範囲であるならば特に限定しないがＡc_1 点＋５０℃未満になると強度の著しい低下をきたし、またＡc_3 点－５０℃以上では降伏比が高くなる傾向があるため、Ａc_1 点＋５０℃～Ａc_3 点－５０℃の温度範囲とするのがが好ましい。直接焼入れ時およびＡc_3 ～Ａc_1 点からの冷却速度は特に限定しないが空冷より速い速度とする。

【００２１】その後、Ａc_1 点以下の温度に加熱して冷却する焼戻し処理を行う。焼戻し温度は、強度、耐サワー性および靭性の安定化を確保するために行うもので、Ａc_1 点以下であれば良い。その加熱方法については特に限定しない。

【００２２】以上の製造条件で得られる鋼管は、γ粒のばらつきがなく、細粒組織で且つ高強度、低降伏比で耐サワー性、靭性の諸特性を具備する必要のあるシームレス鋼管に好適である。

【００２３】

【実施例】表１に示す成分の溶鋼を転炉で精錬し、該溶鋼を連続鋳造で鋳片とし、これを以下に示す条件で、シームレス圧延－直接焼入れおよび引続きＡc_1 ～Ａc_3 点への加熱急冷する二相域処理、Ａc_1 以下の焼戻し処理を施した。

【００２４】本発明の鋳片処理条件は以下の通りである。

鋳片加熱温度	：１２００℃
熱間穿孔連続圧延の最終圧延	：８５０℃×５%
再加熱開始温度	：Ａr_3 －７５℃～Ａr_3 ＋５０℃
最終仕上圧延温度	：８５０℃
最終仕上圧下量	：２０%
直接焼入れ温度	：９００℃
二相域加熱温度	：７８０～８６０℃
焼戻し温度	：６００℃

また、比較例として下記の処理を施した。

加熱温度	：１２００℃
熱間穿孔連続圧延の最終圧延	：９５０℃×５%
※再加熱開始温度	：Ａr_3 ＋５０℃
最終仕上圧延温度	：８５０℃
最終仕上圧下量	：２０%

再加熱焼入れ温度　　　　　：950℃
焼戻し温度　　　　　　　　：600℃

【0025】上記処理によって得られたシームレス鋼管の特性（降伏強度、降伏比、耐SCC性）を表2に示す。耐SSC性は、NACE　TM01－77に従った荷重方式によるσth（Threshold Stress）を求めて評価した。これから明らかのように本発明によって製造された鋼管は、高強度、低降伏比で耐サワー性が得られていることがわかる。

【0026】
【表1】

	鋼	化学成分 (wt%)																	
		C	Si	Mn	P	S	Al	Ti	Nb	Mo	Cr	Ni	V	Ce	B	Co	Cu	Ca	N
本発明法	1	.05	.21	1.44	.014	.002	.032	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	2	.04	.24	1.37	.015	.002	.032	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	3	.04	.25	1.45	.015	.002	.032	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	4	.04	.25	1.44	.014	.002	.036	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	5	.15	.23	1.43	.003	.002	.034	.013	.00	.00	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	6	.15	.24	1.48	.002	.002	.034	.015	.00	.00	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	7	.15	.24	1.45	.002	.002	.036	.015	.00	.00	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	8	.15	.26	1.43	.003	.002	.036	.015	.00	.22	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	9	.13	.44	0.80	.011	.002	.026	.025	.00	.00	.00	.00	.000	.0001	.001	.000	.00	.0010	.003
	10	.13	.42	0.80	.011	.002	.025	.025	.00	.00	.00	.00	.000	.0001	.001	.000	.00	.0010	.003
	11	.13	.42	0.82	.011	.002	.024	.025	.00	.00	.00	.25	.000	.0001	.001	.008	.22	.0010	.003
	12	.12	.41	0.81	.011	.002	.024	.025	.00	.22	.00	.00	.000	.0001	.001	.000	.00	.0010	.003
従来法	17	.11	.15	1.30	.021	.005	.031	.010	.00	.10	.00	.00	.00	.0001	.000	.000	.00	.0000	.005
	18	.11	.15	1.30	.025	.005	.027	.015	.00	.15	.00	.00	.00	.0001	.000	.000	.00	.0000	.005
	19	.12	.15	1.30	.025	.005	.028	.015	.00	.13	.00	.00	.00	.0001	.000	.000	.00	.0000	.005
	20	.12	.15	1.31	.025	.005	.021	.015	.00	.14	.06	.00	.00	.0001	.000	.000	.00	.0000	.005
	21	.16	.25	0.95	.025	.005	.001	.000	.00	.00	.00	.00	.00	.0001	.000	.000	.00	.0000	.004
	22	.16	.25	0.95	.025	.005	.006	.000	.03	.00	.00	.00	.00	.0001	.000	.000	.00	.0000	.004
	23	.16	.25	0.95	.024	.005	.007	.000	.03	.00	.14	.00	.00	.0001	.000	.000	.00	.0000	.004
	24	.16	.25	0.95	.025	.005	.005	.000	.03	.00	.10	.00	.00	.0001	.000	.000	.00	.0000	.004

【0027】

【表2】

	鋼	降伏強度 kg/mm²	降伏比 %	耐SSC性 (σth/σy)
本発明法	1	46.3	75	0.9
	2	43.3	75	0.9
	3	43.2	74	0.9
	4	46.7	76	0.9
	5	45.8	76	0.9
	6	45.3	75	0.9
	7	43.3	77	0.9
	8	47.1	78	0.9
	9	58.4	82	0.9
	10	59.1	81	0.9
	11	63.6	80	0.9
	12	63.6	84	0.9
従来法	17	44.7	89	0.8
	18	46.4	89	0.8
	19	43.2	88	0.85
	20	53.1	90	0.8
	21	55.4	91	0.85
	22	56.6	92	0.8
	23	53.6	92	0.8
	24	53.6	91	0.85

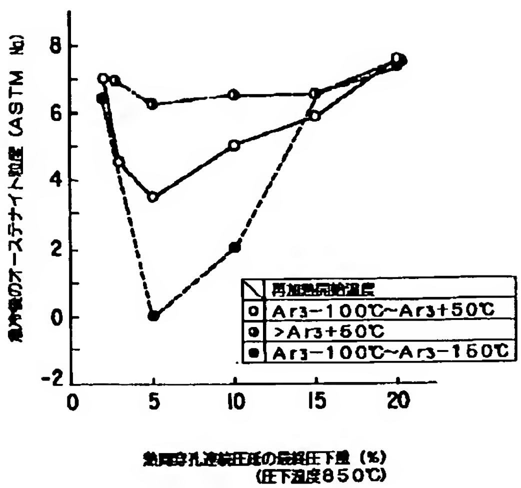
【0028】
【発明の効果】上記のような本発明法によって製造された鋼管は、高強度降伏比であり、耐サワー性に優れ、劣悪な油井環境において使用される。

【図面の簡単な説明】

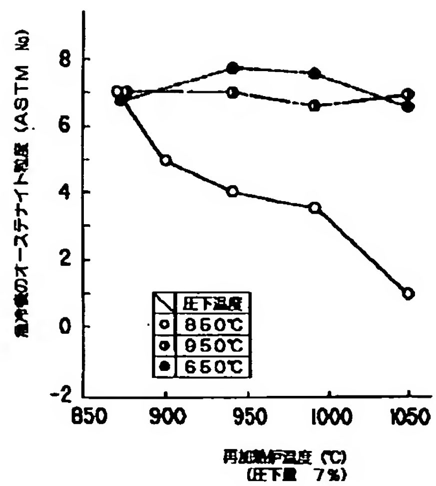
【図1】急冷後のオーステナイト粒度に及ぼす再加熱開始温度と熱間穿孔連続圧延の最終圧下率の影響を示す図。

【図2】急冷後のオーステナイト粒度に及ぼす圧下温度と再加熱炉温度との影響を示す図。

【図1】


急冷後のオーステナイト粒度 (ASTM No)
8
6
4
2
0
-2
0
5
10
15
20
Ar3－100℃～Ar3＋50℃
＞Ar3＋50℃
Ar3－100℃～Ar3－150℃
(圧下温度850℃)

【図2】


急冷後のオーステナイト粒度 (ASTM No)
8
6
4
2
0
-2
850
900
950
1000
1050
圧下温度
850℃
950℃
650℃
再加熱炉温度 (℃)
(圧下量　7%)

CLAIMS

[Claim(s)]
[Claim 1] As weight %, it is C. : 0.02% - 0.20%, Si:0.01%-0.5%, Mn: 0.15%-2.5%, P : 0.020% or less, S : 0.010% or less, aluminum: 0.005%-0.1%, Ti:0.005%-0.1%, N : 0.01% or less is contained. Perform slab with which the remainder consists of Fe substantially in the last process of hot-piercing continuation rolling, and processing of 3 - 15% of rolling reduction is performed at the temperature of 900-700 degrees C. Ar3 Point-100 degree-C-Ar3 The hollow element tube which dropped the temperature of +50 degrees C of points Finishing temperature is Ar3 after heating among 900-1000 degrees C higher than this element tube temperature. Heat finish rolling of +50 degrees C or more of points is performed. It is obtained finished steel tubing Ar3 Ac1 -Ac3 after performing hardening processing which quenches from the temperature beyond a point It quenches, after heating to the temperature between points, and subsequently it is Ac1. It is the high intensity characterized by carrying out tempering processing which carries out heating cooling to the temperature below a point, and is the manufacture approach of a low yield ratio seamless steel pipe.
[Claim 2] They are Cr:0.1%-1.5%, Mo:0.05%-0.5%, nickel:0.1%-2.0%, and V as weight % further as a slab component. : 0.01% - 0.1%B : It is the high intensity according to claim 1 characterized by containing at least one sort chosen from the element of a group which consists of 0.0003% - 0.0030%, and is the manufacture approach of a low yield ratio seamless steel pipe.
[Claim 3] It is high intensity claim 1 characterized by containing at least one sort chosen from the element of a group which consists of rare-earth-elements:0.001%-0.05%, calcium:0.001%-0.02%, Co:0.05%-0.5%, and Cu:0.1%-0.5% as weight %, or given in two further as a slab component, and is the manufacture approach of a low yield ratio seamless steel pipe.

[Translation done.]

* NOTICES *

JPO and NCIPI are not responsible for any damages caused by the use of this translation.

1.This document has been translated by computer. So the translation may not reflect the original precisely.
2.**** shows the word which can not be translated.
3.In the drawings, any words are not translated.

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Field of the Invention] This invention relates to the manufacture approach of the seamless steel pipe which is high intensity and is a low yield ratio.
[0002]
[Description of the Prior Art] The low property of a yield ratio is required from a viewpoint which raises the safety to destruction as for the seamless steel pipe used for the line pipe which conveys the object for digging or petroleum, such as an oil well, and natural gas. In order to consider as a low yield ratio steel pipe with a hot-rolling seamless steel pipe, normalizing processing which reheats and carries out air cooling to as [rolling] or an after [rolling] austenite region is performed, and there is the approach of making it systematically the two-layer organization of a ferrite pearlite. However, by such approach, the high intensity of API-X grade is not obtained in any. On the other hand, in order to high-intensity-ize, when hardening-tempering processing was carried out, there was a problem that a low yield ratio could not be attained.
[0003] It is the steel which has the mixed organization of a ferrite and a pearlite in ordinary temperature in JP,2-282427,A in order to solve such a problem Ac1 +10 degrees C of transformation points to Ac1 Heating and quick cooling-after retention processing are performed to the temperature of +90 degrees C of transformation points, and the manufacturing method of the low high intensity steel pipe of the maximum hardness which carries out the afterbaking return processing, and a yield ratio is indicated. Moreover, they are heating and water cooling to the two-layer temperature region from hardening (930 degree-Cx10min water cooling) processing material (bainite subject organization) about the Nb-Mo system steel pipe rolled out by "the ingredient and the process" (4 3 No. Vol. 1991 Iron and Steel Institute of Japan and 121st lecture (spring) convention draft 552) at the seamless process. - It is shown that temper is carried out and low yield ratio material is obtained. Punching rolling of the slab containing Ti and Nb is carried out, furthermore, by JP,3-64415,A, after reheating the element tube which carried out the temperature reduction and carrying out finish rolling, it quenches, and tempering processing is carried out and the manufacturing method of the high toughness seamless steel pipe of a fine grain organization is indicated.
[0004]
[Problem(s) to be Solved by the Invention] However, in seamless rolling between heat, since ASTM No.1-6 and dispersion had the large austenite grain size after rolling, there was a problem that the seamless steel pipe by which reinforcement and a yield ratio were stabilized was not obtained even if it performs the above-mentioned heat treatment. This invention solves such a problem, and it is the high intensity stabilized by controlling a steel component and rolling / heat treatment conditions, and aims at offering the manufacturing method of the seamless steel pipe of a low yield ratio.
[0005]
[Means for Solving the Problem] That is, this invention makes the following configurations a summary. As weight % C : 0.02% - 0.20%, Si: 0.01%-0.5% Mn:0.15%-2.5%, P : 0.020% or less S : 0.010% or

less, aluminum: 0.005%-0.1% Ti:0.005%-0.1%, N : 0.01% or less is contained and the need is accepted further. Cr:0.1%-1.5%, Mo: 0.05%-0.5% nickel:0.1%-2.0%, V : 0.01% - 0.1% B : The 1st group element which consists of 0.0003% - 0.0030%, Rare earth elements : 0.001% - 0.05%, calcium:0.001%-0.02%, It is the 2nd group element which consists of Co:0.05%-0.5% and Cu:0.1%-0.5%. The slab which was chosen from both this group and with which a kind is contained at least and the remainder consists of Fe substantially Processing of 3 - 15% of rolling reduction is performed at the temperature of 900-700 degrees C by the last process of hot-piercing continuation rolling. Ar3 The hollow element tube which dropped -100 degrees C [of points] - three Ar(s) temperature of +50 degrees C Finishing temperature is Ar3 after heating among 900-1000 degrees C higher than this element tube temperature. Heat finish rolling of +50 degrees C or more of points is performed. It is obtained finished steel tubing Ar3 After performing hardening processing which quenches from the temperature beyond a point, Ac1 - Ac3 After heating to the temperature between points, it sudden-**, and subsequently it is Ac1. It is the high intensity characterized by carrying out tempering processing which carries out heating cooling to the temperature below a point, and is the manufacturing method of a low yield ratio seamless steel pipe.
[0006]
[Embodiment of the Invention] The manufacturing method of this invention is explained to a detail below. First, the reason limited to the above steel components in this invention is explained. A quenching effect is increased, reinforcement is raised and C and Mn are 2 the 40 to 60 kgf/mm yield point. It is important in order to be stabilized and to obtain high tensile steel, and in order to reduce a yield ratio. When too few, the effectiveness did not exist, and when many [too], induction of a quench crack, and in order to form a high degree of hardness and to cause the fall of SSC-proof nature, they could be 0.02 - 0.20%, and 0.15 - 2.5%, respectively.
[0007] Si is that in which the deoxidizer remained, and in order that it may raise reinforcement, it is an effective component for which a yield ratio is reduced. When too few, the effectiveness did not exist, and if many [too], in order to increase inclusion and to reduce SSC-proof nature, it could be 0.01 - 0.5%.
[0008] Grain boundary segregation was started, P was a harmful component that it is easy to produce a crack in the case of processing, and it made the content 0.020% or less in order to cause degradation of low-temperature toughness. S forms MnS system inclusion, is extended with heat continuation rolling, forms the lamellar structure, and improves the destructive communicability ability of steel. When too few, the effectiveness did not exist, and it could be 0.01%, in order to increase inclusion and to stiffen the property of steel, if many [too].
[0009] aluminum is that in which the deoxidizer remained like Si, it combines with N contained as an impurity component in steel, stops grain growth, and improves the destructive communicability ability of steel. When too few, the effectiveness did not exist, and if many [too], in order to increase inclusion and to stiffen the property of steel, it could be 0.005 - 0.1%.
[0010] Ti is the most important element as a diameter control element of crystal grain under seamless rolling. It demonstrates the hardenability of the below-mentioned B from deoxidation and an operation of denitrification, and raises reinforcement while Ti combines with N contained as an impurity component in steel, stops the grain growth after the crystal grain control under hot rolling, and hot rolling and improves the destructive communicability ability of steel. When too few, the effectiveness did not exist, and if many [too], in order to deposit TiC and to embrittle steel, it could be 0.005 - 0.1%. N made the content 0.01% or less as a harmful component for which the hardenability of the below-mentioned B is reduced.
[0011] When the steel of the above-mentioned component presentation raises the reinforcement of steel further, components, such as Cr, are added alternatively if needed. Cr, Mo, nickel, and V increase the hardenability of steel, and they are added in order to raise reinforcement. Even if many [when too few the effectiveness did not exist, and / too], the effectiveness was saturated, since it was moreover very expensive, the top and the minimum were limited about each, in Cr, 0.05 - 0.5% and nickel were made into 0.1 - 2.0%, and 0.1 - 1.5% and Mo made V 0.01 - 0.1%. Moreover, B makes hardenability improve remarkably and raises reinforcement. When too few, the effectiveness did not exist, and even if many

[too], while effectiveness did not change, since toughness and hot-working nature were degraded, it made the content range 0.0003 - 0.0030%. What is necessary is just to add each element of Above Cr thru/or B alternatively if needed.

[0012] Furthermore, this invention adds alternatively components, such as rare earth elements, and calcium, Co, Cu, if needed, in order to improve the SSC-proof nature of the steel which consists of above-mentioned component presentations in view of the operating environment of a seamless steel pipe in recent years. Rare earth elements and calcium are effective components which the gestalt of inclusion is made to spheroidize and are defanged. Rare earth elements were been, when too few, the effectiveness did not exist, and since inclusion is increased and SSC-proof nature was reduced when many [too], calcium could be 0.001 - 0.02% 0.001 to 0.05%. Co and Cu have the hydrogen invasion depressor effect to the inside of steel, and work effective in SSC-proof nature. Co was, when too few, the effectiveness did not exist, and since the effectiveness would be saturated if many [too], Cu could be 0.1 - 0.5% 0.05 to 0.5%.

[0013] Next, the reason which limited the seamless rolled bar affair between heat as mentioned above is explained. The steel of the above component presentations is fusion furnaces, such as a converter and an electric furnace, or is further ingoted through vacuum-degassing processing, and manufactures slab by the continuous casting process or the ingot making cogging method. **** heats slab to the once cooled back elevated temperature immediately, and hot-piercing rolling is performed. Whenever [stoving temperature] must be made sufficiently high in order to make hot-piercing rolling easy. Since trouble did not arise at all even if it will carry out hot-piercing processing at the temperature of 1200 degrees C or more, if it is the steel of this invention component within the limits, whenever [stoving temperature] was made into 1000-1250 degrees C.

[0014] The slab between heat is conveyed by the continuous mill between punching rolling post heating, is rolled out by a target outer diameter and thickness, and is rough-fabricated to a hollow element tube. This rolling has big effect on the quality of the material of the manufactured steel pipe especially a grain size number, and a yield ratio. Drawing 1 and drawing 2 show the relation between gamma grain size of the steel pipe (table 1 steel component of No.5) which carried out quenching processing after rolling, and the rolled bar affair in the last process of hot-piercing continuation rolling, reheating initiation temperature and reheating furnace temperature in order to investigate the austenite grain size immediately after rolling. As shown in drawing, gamma grain size immediately after rolling changes with monograph affairs a lot with ASTM No.0-8.

[0015] According to research of this invention etc., it is API. It traced that it was necessary to set to ASTM No.3-5 gamma grain size with which are satisfied of the low-temperature toughness demanded by the yield ratio of the high-strength steel of X grade class being influenced by the grain size number before hardening processing, and a yield ratio falling, so that the diameter of crystal grain is comparatively large, a yield ratio, line pipe material, etc. Moreover, it found out that use of gamma grain big and rough-ized phenomenon caused by the secondary recrystallization after the distorted induction grain growth which takes place from the last process of hot-piercing continuation rolling to obtaining gamma grain size of ASTM No.3-5 by reheating was indispensable.

[0016] gamma grain-size control using distortion induction grain growth becomes possible by specifying the rolled bar affair in the last process of hot-piercing continuation rolling, reheating initiation temperature, and reheating furnace temperature as follows. That is, in 900-degree-C **, since the strain energy introduced by processing falls with recovery and recrystallization, in order that the driving force of distortion induction grain growth may disappear, big and rough-ization of the diameter of crystal grain does not take place, but the pressing-down temperature in the ultimate-pressure total of hot-piercing continuation rolling checks the fall of the yield ratio of a steel pipe. Therefore, the pressing-down temperature in the last process of hot-piercing continuation rolling is limited to 900-700 degrees C.

[0017] In this hot-piercing continuation rolling, 0 - 2% of a rolling draft is [the driving force of distortion induction grain growth] insufficient, at 15% or more, in order that the driving force of distortion induction grain growth may disappear by gamma grain growth in which the strain energy

accumulated becomes large too much, and does not have strain energy after pressing down or in a subsequent reheating process, big and rough-ization of the diameter of crystal grain does not take place, but the fall of the yield ratio of a steel pipe is checked. Therefore, the rolling draft in the last process of hot-piercing continuation rolling was limited to 3 - 15%.
[0018] It is 850 degree-C-Ar1 after pressing down. Although hollow rough tubing which descended to the temperature of a point is reheated and finish rolling is carried out In - with an Ar of three to 100 degree C three to 150 degree C Ar, rapid abnormality big and rough-ization of gamma grain takes place, and low-temperature toughness deteriorates remarkably, and the driving force of distortion induction grain growth disappears at 3+50 degree C of Ar(s), and moderate gamma grain big and rough-ization does not take place, but this reheating initiation temperature checks the fall of the yield ratio of a steel pipe. Therefore, reheating initiation temperature after pressing down is set to 3+50 degree C of - with an Ar of three to 100 degree C Ar(s). On the other hand, if hardening temperature after the last finish rolling between heat cannot be secured and it exceeds 1000 degrees C, while less than 900 degrees C of reheating temperature are insufficient for gamma grain growth, while rapid big and rough-ization of gamma grain breaks out and low-temperature toughness deteriorates remarkably, a lot of scale arises on a steel front face, and it has a bad influence on the surface grace of a steel pipe. Therefore, reheating temperature at the time of finish rolling is made into the temperature of 900 degrees C - 1000 degrees C.

[0019] In the hollow element tube heated by 900-1000 degrees C, finishing temperature is Ar3. The last finish rolling between heat used as +50 degrees C or more of points is performed, and hardening processing is performed to obtained finished steel tubing. It is Ac3 -Ac1 which the cooling initiation temperature after the last finish rolling between heat serves as stable sufficient hardening organization, and secures the reinforcement, the sour-proof nature, and the toughness to need, and is performed after hardening processing. The need of securing the homogeneity of an organization acquired by the quenching processing from a point to Ar3 It carries out in +50 degrees C or more of points.
[0020] Ar3 After performing hardening processing which quenches from +50 degrees C or more of points, it is Ac3 -Ac1 continuously. It reheats at a point and quenching processing is performed after that. This processing is an important process on this invention for obtaining the high intensity and the low yield ratio of a fine grain organization. Reheating temperature influences target reinforcement and a yield ratio greatly. this temperature -- Ac3 -Ac1 it is the range -- especially if it becomes, although it will not limit -- Ac1 if it becomes less than +50 degrees C of points -- a strong remarkable fall -- causing -- moreover, Ac3 since there is an inclination for a yield ratio to become high at -50 degrees C or more of points -- Ac1 Point +50 degree-C-Ac3 considering as the temperature requirement which is -50 degrees C of points -- ** -- it is desirable. The time of direct quenching, and Ac3 -Ac1 Although especially the cooling rate from a point is not limited, let it be a rate quicker than air cooling.
[0021] Then, Ac1 Tempering processing heated and cooled to the temperature below a point is performed. It carries out for accumulating and tempering temperature is [which secures stabilization of reinforcement, sour-proof nature, and toughness] Ac1. What is necessary is just below a point. It does not limit especially about the heating approach.
[0022] The steel pipe obtained on the above manufacture conditions is suitable for the seamless steel pipe which there is no dispersion in gamma grain, and is a fine grain organization, and has the need of providing sour-proof nature and many properties of toughness by high intensity and the low yield ratio.
[0023]
[Example] the conditions which refine with a converter the molten steel of the component shown in Table 1, make this molten steel a cast piece by continuous casting, and show this below -- seamless rolling-direct quenching -- and -- succeedingly -- Ac1 -Ac3 The two phase region processing to a point which carries out heating quenching, and Ac1 The following tempering processings were performed.
[0024] The cast piece processing conditions of this invention are as follows.
Whenever [cast piece stoving temperature] : 1200 degrees C The ultimate-pressure total of hot-piercing continuation rolling : 850 degree-Cx5% Reheating initiation temperature : 3+50 degree C of - with an Ar of three to 75 degree C Ar(s) The last finish rolling temperature : 850 degrees C The last finish

rolling draft : 20% Direct-quenching temperature : 900 degrees C Whenever [two phase region stoving temperature] : 780-860 degrees C Tempering temperature : 600 degrees C of the following processings were performed as an example of a comparison again.
Whenever [stoving temperature] : The ultimate-pressure total of 1200 degree-C hot-piercing continuation rolling: 950 degree-Cx5% reheating initiation temperature : The Ar3 +50-degree-C last finish rolling temperature : The 850-degree-C last finish rolling draft : 20% reheating hardening temperature : 950-degree-C tempering temperature : 600 degrees C [0025] The property (yield strength, a yield ratio, SCC-proof nature) of the seamless steel pipe obtained by the above-mentioned processing is shown in Table 2. SSC-proof nature is NACE. It evaluated in quest of sigmath (Threshold Stress) by the load method according to TM 01-77. As for the steel pipe manufactured by this invention from now on so that clearly, it turns out that sour-proof nature is obtained by high intensity and the low yield ratio.

[0026]
[Table 1]

	鋼	化学成分 (wt%)																	
		C	Si	Mn	P	S	Al	Ti	Nb	Mo	Cr	Ni	V	Ce	B	Co	Cu	Ca	N
本発明法	1	.05	.21	1.44	.014	.002	.032	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	2	.04	.24	1.37	.015	.002	.032	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	3	.04	.25	1.45	.015	.002	.032	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	4	.04	.26	1.44	.014	.002	.036	.005	.00	.00	.00	.00	.004	.0000	.000	.000	.00	.0005	.003
	5	.15	.23	1.43	.003	.002	.034	.013	.00	.00	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	6	.15	.24	1.48	.002	.002	.034	.015	.00	.00	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	7	.15	.24	1.45	.002	.002	.036	.015	.00	.00	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	8	.15	.26	1.43	.003	.002	.036	.015	.00	.22	.18	.00	.000	.0000	.000	.000	.00	.0008	.004
	9	.13	.44	0.80	.011	.002	.026	.025	.00	.00	.00	.00	.000	.0001	.001	.000	.00	.0010	.003
	10	.13	.42	0.80	.011	.002	.025	.025	.00	.00	.00	.00	.000	.0001	.001	.000	.00	.0010	.003
	11	.13	.42	0.82	.011	.002	.024	.025	.00	.00	.00	.26	.000	.0001	.001	.008	.22	.0010	.003
	12	.12	.41	0.81	.011	.002	.024	.025	.00	.22	.00	.00	.000	.0001	.001	.000	.00	.0010	.003
従来法	17	.11	.15	1.30	.021	.005	.031	.010	.00	.10	.00	.00	.00	.0001	.000	.000	.00	.0000	.005
	18	.11	.15	1.30	.025	.005	.027	.015	.00	.15	.00	.00	.00	.0001	.000	.000	.00	.0000	.005
	19	.12	.15	1.30	.025	.005	.028	.015	.00	.13	.00	.00	.00	.0001	.000	.000	.00	.0000	.005
	20	.12	.15	1.31	.025	.005	.021	.015	.00	.14	.06	.00	.00	.0001	.000	.000	.00	.0000	.005
	21	.16	.25	0.95	.025	.005	.001	.000	.00	.00	.00	.00	.00	.0001	.000	.000	.00	.0000	.004
	22	.16	.25	0.95	.025	.005	.006	.000	.03	.00	.00	.00	.00	.0001	.000	.000	.00	.0000	.004
	23	.16	.25	0.95	.024	.005	.007	.000	.03	.00	.14	.00	.00	.0001	.000	.000	.00	.0000	.004
	24	.16	.25	0.95	.025	.005	.005	.000	.03	.00	.10	.00	.00	.0001	.000	.000	.00	.0000	.004

[0027]
[Table 2]

	鋼	降伏強度 kg/mm²	降伏比 %	耐SSC性 (σth/σy)
本発明法	1	46.3	75	0.9
	2	43.3	75	0.9
	3	43.2	74	0.9
	4	46.7	76	0.9
	5	45.8	76	0.9
	6	45.3	75	0.9
	7	43.3	77	0.9
	8	47.1	79	0.9
	9	58.4	82	0.9
	10	59.1	81	0.9
	11	63.6	80	0.9
	12	63.6	84	0.9
従来法	17	44.7	89	0.8
	18	46.4	89	0.8
	19	43.2	88	0.85
	20	53.1	90	0.8
	21	55.4	91	0.85
	22	56.6	92	0.8
	23	53.6	92	0.8
	24	53.6	91	0.85

[0028]
[Effect of the Invention]